FiNZ 2019

7th NZ fluid mechanics conference

31 January - 1 February, Dunedin

Conference booklet

UNIVERSITY of OTAGO
Te Whare Wānanga o Otāgo
NEW ZEALAND
SAPERE AUDE

Welcome to FiNZ 2019

...and welcome to the University of Otago, which hosts FiNZ for the first time since the inaugural event in 2013. Thank you for travelling from all corners of New Zealand to be here and participate in the conference.

We have a busy conference schedule ahead. We hope that you enjoy the conference, and that it provides plenty of opportunities for you to connect with our fluid mechanics community.

Organising Committee

Fabien Montiel, Sam Lowrey, Sarah Wakes, Alice Harang.

Thanks to our sponsors

- The Department of Physics at the University of Otago (particularly Prof. Craig Rodger)
- The Otago Energy Research Centre (OERC)
- The New Zealand Mathematical Society (NZMS)

We also thank

Leanne Kirk, John Shanks, Marguerite Hunter, Louise Schumacher and Jane Reynolds for administrative and technical support.

The Organising Committee.

Thursday, 31st January

0840-0845 Welcome

0845-1030 Session 1: Multi-phase and multi-scale fluid physics (chair: Fabien Montiel)

0845 **Invited Speaker**: Ashton Bradley (Otago)
Observing a quantum storm in a superfluid teacup

0930 Emilia Nowak (Massey)
On the vortex formation upon drops coalescence

0945 Bradley Boyd (Canterbury)
Numerical simulations of an acoustically-driven cavitation bubble near a wall: investigation of the growth and collapse behavior at various standoff distances

1000 Zhifa Sun (Otago)
Rayleigh-Bénard-Marangoni cellular convection with transient gas-liquid mass transfer

1015 Jonathan Squire (Otago)
The interesting fluid dynamics of planet formation

1030-1100 Coffee + poster session

1100-1230 Session 2: Fundamental fluid mechanics (chair: Colin Whittaker)

1100 Natalia Kabaliuk (Canterbury)
Dynamics of drip bloodstain formation on fabrics: how big can small be?

1115 James Ramsay (Canterbury)
Preventing boundary layer separation with non-uniform suction

1130 Jacob Cohen (Technion-Israel Institute of Technology)
Subcritical transition in wall-bounded shear flows

1145 Alex Meredith (Canterbury)
Interactions between developed gravity currents and rough boundaries

1200 Craig McConnochie (Canterbury)
Enhanced entrainment into turbulent plumes driven by suspended sediment

1215 Ryan McKinlay (Callaghen Innovation)
Water tunnel design and commissioning

1230-1330 Lunch

1330-1515 Session 3: Flows in geophysics (chair: Ata Suanda)

1330 Craig Stevens (NIWA/Auckland)
Ocean mixing at large Reynolds number: observations from Cook Strait

1345 Pete Russell (Otago)
High resolution observations of an outer bank cell of secondary circulation in a natural river bend

1430 Natalie Robinson (NIWA)
Physics of the ice-ocean boundary layer in the presence of accreted ice crystals

1445 Martin Forbes (Otago)
Modelling rifts of the Ross Ice Shelf

1430 **Invited Speaker**: Christina Hulbe (Otago)
Dynamics of the marine ice sheet instability on Thwaites Glacier, West Antarctica

1515-1545 Coffee

Thursday, 31st January (ctd)

1545-1715 Session 4: Fluids in energy and engineering (chair: Alice Harang)

1545 Ben Wilks (Otago)
Scattering modes of cylindrical Helmholtz resonators

1600 James Hewett (Canterbury)
Viscous dampers with circular orifices using silicone oil

1615 Illia Chryva (Canterbury)
Rotor-rotor interaction of remotely piloted multicopters and their influence on an on-board spraying system

1630 Alan Caughley (Callaghan Innovation) & Nikhil Vishwanath (Road Science)
Modelling of bitumen emulsion

1645 Zeineldin Elserfy (Auckland)
Reduction of wind turbine noise using porous trailing edges

1700 Sarah Wakes (Otago)
Understanding the stall behaviour of a one-blade wind turbine

1730-1830 General meeting

1830-2030 Conference BBQ

Friday, 1st February

0830-1015 Session 5: Microfluidics and nanofluidics (chair: Sam Lowrey)

0830 **Invited Speaker**: Shaun Hendy (Te Pūnaha Matatini)
Molecular dynamics simulations for nano and microfluidic flows

0915 Lily Panton (Auckland)
Experimental study of evolution of drop impact force

0930 Santhosh Kumar (Auckland)
Drop impact of high viscosity and non-Newtonian fluids on patterned polymer surfaces

0945 Geoff Willmott (Auckland)
Inertial capillary uptake of droplets

1000 Matheu Broom (Auckland)
Symmetry splitting of impacting droplets on partly wetting surfaces

1015-1045 Coffee + poster session

1045-1230 Session 6: Fluids in biology (chair: Emilia Nowak)

1045 Theodore Lerios (Canterbury)
Determining changes in patient respiratory mechanics using non-linear autoregressive models of pulmonary elastance

1100 Thiwanka Palmada Kankanamalage (Auckland)
Modelling flow and mixing in the proximal small intestine

1115 Richard Clarke (Auckland)
Permeability as a function of microstructure in the endothelial glycocalyx

1130 Arun Kumar Manickavasagam (Canterbury)
Effects of non-neighbouring members in small-sized arrays

1145 Sina Yazdi (Canterbury)
In-vitro measurement of hemodynamics in rigid and compliant silicone replicas of aortic arch using stereoscopic particle image velocimetry

1200 Paul Docherty (Canterbury)
Integral-based reconstruction of static pressure in a compliant axisymmetric vessel using velocity field data from particle image velocimetry (PIV) analysis

1215 Petra Williamson (Canterbury)
Particle image velocimetry (PIV) analysis of haemodynamics distal of a frozen elephant trunk stent phantom

1230-1330 Lunch

1330-1515 Session 7: Coastal hydrodynamics (chair: Natalie Robinson)

1330 **Invited Speaker**: Julia Mullarney (Waikato)
Reconciling multiple spatial and temporal scales: hydrodynamics within mangrove forests

1415 Mark Battley (Auckland)
Characterisation of wave impacts on coastal structures

1430 Ahmadreza Ebadati (Auckland)
Modelling of wave run-up for coastal structures

1445 Alice Harang (Otago)
Numerical study of mudflow resuspension in estuaries: influence of the viscosity and viscoplastic threshold on shear instabilities

1500 Colin Whittaker (Auckland)
Lagrangian particle transport by wave groups in finite water depth

1515-1545 Coffee

Friday, 1st February (ctd)

1545-1715 Session 8: Fluids in geology and agriculture (chair: Sarah Wakes)

1545 Boris Baeumer (Otago)
Modelling deposition and erosion of clay in an aquifer

1600 Jason Chen (Canterbury)
Modelling the lifecycle of amorphous silica scaling during geothermal reinjection

1615 Mathieu Sellier (Canterbury)
Modelling the flow in a fracture network by patching Hele-Shaw cells

1630 Luke Longworth (Canterbury)
Electrostatic spraying to increase efficiency and reduce pollution

1645 Frederick Wells (Auckland)
Milk spray drying without sticking

1700 Miguel Balzan (Auckland)
Bubble characteristics inside an effervescent atomizer

1715 Scott Post (Lincoln Agritech)
Granular flow properties of lime

1730-1740 Wrap-up

Poster Sessions

Michael Coe (Canterbury)
UC-Ika series of underwater robots

Bibin Jose (Canterbury)
A study on the effect of an axisymmetric cavity in coaxial supersonic stream

Vishnu Charan Kuduva Janarthanan (Auckland)
Resilient heat exchange surface for fouling environments: can surface functionalization improve heat transfer?

Sam Lowrey (Otago)
A survey of optical lithographic techniques for modified surface wetting

Ali Mohammadi Sefidan (Canterbury)
Multi-layer Phase Change Materials in tubular and rectangular shaped cylinders

Ata Suanda (Otago)
High-frequency temperature oscillations on the Otago inner shelf

Invited Speakers

Ashton Bradley, Department of Physics, University of Otago

Observing a quantum storm in a superfluid teacup

Atomic Bose-Einstein condensates (BECs) provide a uniquely controllable setting in which to study quantum fluid dynamics. In a stirred superfluid, quantized vortices typically proliferate, injecting linear and angular momentum into the fluid. In 1949, while studying the point-vortex model, Onsager predicted that confinement of quantum vortices can produce a surprising result: the possibility of vortices reaching negative temperatures. Negative temperature states contain significant energy, forming a collective storm of vortices circulating in the same direction: a giant vortex cluster. Vortex cluster states are the quantum analogue of the Great Red Spot, visible on the surface of Jupiter as a manifestation of classical fluid turbulence. I will describe our work on the theory of giant vortex clusters, and joint work with the BEC group at the University of Queensland to observe them for the first time in a quantum gas controlled by a digital micromirror device. Despite expectations that such high energy states should be unstable, we observe giant quantum vortex clusters with very long lifetimes. Our work confirms Onsager's prediction after some 70 years, and opens the door to a new regime for quantum vortex matter at negative absolute temperatures, with implications for quantum turbulence, helium films, nonlinear optical materials, and fermi superfluids.

Shaun Hendy, Department of Physics, University of Auckland

Molecular dynamics simulations for nano and microfluidic flows

Molecular dynamics is a numerical technique for simulating the evolution of many-body systems by solving Newton's equations of motion for hundreds to hundreds of millions of particles (atoms or otherwise). In this talk I will illustrate its use for understanding nano and microfluidic flows. Even at scales where continuum descriptions of fluids are expected to hold, interfacial properties often have to be modelled in an ad hoc fashion, with model parameters that extracted from difficult to obtain experimental data. In molecular dynamics, however, these properties are an emergent feature of a simulation, arising naturally from the corresponding many-body interactions. While molecular dynamics has many practical shortcomings, including restriction to short simulation times and small system sizes, it allows for computational experiments that don't require ad hoc modelling of chemical or interfacial phenomena. I will illustrate this by describing our recent work on the simulation of droplets moving on complex surfaces and the aggregation of Janus particles in uniform or shear flows.

Christina Hulbe, National School of Surveying, University of Otago

Dynamics of the marine ice sheet instability on Thwaites Glacier, West Antarctica

Rapid change now underway on in the Amundsen Sea sector of West Antarctica raises concern that a threshold for unstoppable grounding line retreat has been or is about to be crossed. The grounding line is transition between ice that is resting on the sea floor and ice that is floating in the ocean and mathematically, the instability is due to the inland-deepening bed of the glacier together with the power-law relationship between ice thickness and ice flux across the boundary. We use a high-resolution ice sheet model to examine the dynamics of self-sustained retreat on Thwaites Glacier by nudging the grounding line just past the point of instability. We find that by modifying surface slope in the region of the grounding line, the rate of the forcing dictates the rate of retreat, even after the external forcing is removed. Grounding line retreats that begin faster proceed more rapidly because the shorter time interval for the grounding line to erode into the grounded ice sheet means relatively thicker ice and larger driving stress upstream of the boundary. Retreat is sensitive to short-duration re-advances associated with reduced external forcing where the bathymetry allows re-grounding, even when an instability is invoked. The time and location of initiation is also sensitive to the roughness of the subglacial bed due to the flux-regulating effects of local high spots. These obstacles drive transient steepening in the vicinity of the grounding as it passes by and modify form drag in the grounded part of the system. All together, we show that small differences in forcing lead to large differences in retreat rate and ice discharge across the grounding line and the implication for future change is clear. If lower-end future warming scenarios are possible, then the sooner anthropogenic forcing is reduced, the slower the ice sheet response, even if a self-sustaining retreat has been initiated. Retreat may be inevitable past a certain dynamical threshold, but the rate at which the retreat proceeds is not.

Julia Mullarney, Department of Earth & Ocean Sciences, University of Waikato

Reconciling multiple spatial and temporal scales: hydrodynamics within mangrove forests

Mangrove forests are highly productive ecosystems, which provide many physical, societal and ecological services in tropical and subtropical regions. Accurate prediction of the morphological evolution of these areas, in the face of global sea level rise and changes in sediment supply, requires understanding of interactions between vegetation elements, water flows, and sediment transport. This talk will provide an overview of hydrodynamics within mangrove forests. These salt-tolerant trees are characterised by complex aerial root systems (pneumatophores), which protrude many centimetres above the seabed. As the tide propagates into the forest, tide and wave energy is converted into dissipative wake-scale turbulence, through the processes of vortex shedding and eddy generation. We present unique small-scale field measurements, which reveal 'hotspots' of intense turbulence, with values sometimes reaching those observed in surf zones. Turbulence was particularly elevated in the fringing regions between mudflat and forest, although there existed substantial spatial variability. On the forest scale, the enhanced drag exerted on the water column by pneumatophores and tree trunks slows the flow and causes the water surface to tilt. We then observe a rotation of the obliquely incident flows toward an orientation nearly perpendicular to the vegetated/unvegetated boundary. The momentum balances governing the large-scale flow are assessed and indicate the relative importance of friction, winds and depth-averaged pressure forces. Drag coefficients were found to be 10–30 times greater than values usually observed for bottom friction, and the drag induced from pneumatophores was dominant relative to drag from the larger, but sparser, tree trunks.

The ability to predict turbulent stresses acting on the seabed and to formulate accurate drag parameterisations are essential to our ability to reliably model the interplay between vegetation and deposition and/or erosion. Knowledge of these processes is crucial for our understanding of the overall resilience of delta systems, which face an uncertain future worldwide.

Contributed Talks

Boris Baeumer, University of Otago

Modelling deposition and erosion of clay in an aquifer

We develop a system of non-linear PDEs to model the deposition and erosion of clay in an aquifer. We use the powerful finite element package FEniCS to approximate solutions and observe the emergence of channels and lenses. Joint work with Tom Blennerhassett.

Miguel Balzan, Dynamics Microfluidics Laboratory, University of Auckland

Bubble characteristics inside an effervescent atomizer

The link between the gas injection process and the nature of the flow upstream of the discharge nozzle of an effervescent atomizer is studied using high-speed shadowgraphy combined with image analysis. Air injection rates were varied from 0.50 to 3.00 SLPM while the water flow rate test range was from 0.19 to 0.70 LPS. Three nozzle diameters; 0.27, 0.52, and 1.59 mm, were used. The test conditions were selected to ensure bubbly flow conditions inside the atomizer as per standard two-phase flow pattern maps. Existing expressions in the literature for D99 were compared with the experimental results obtained and the findings indicated limited agreement. It was inferred that pipe flow correlations might have limited applicability to effervescent atomizer internal flow. The results indicated that the atomizer operated primarily in a breakup dominant regime since the values for both D99 and D32 were smaller near the discharge nozzle than after bubble detachment occurs. It was concluded that the gas injection conditions play a fundamental role in the fluid dynamics inside the atomizer.

Mark Battley, University of Auckland

Characterisation of wave impacts on coastal structures

Our coastlines are already experiencing the effects of a changing climate, and the cost to maintain traditional coastal protection infrastructure is untenable in many locations. The coastal environment is highly dynamic, and the physics of the wave action and interaction with the coastline and its infrastructure are very challenging to model, significantly limiting our ability to develop novel coastal management systems. To accurately and efficiently predict the dynamic coupling between fluid motion and structural responses we need to understand the time-history of transient hydrodynamic loads and the effect of the wave characteristics on coastal structures.

This presentation will describe the development of experimental and numerical methods to characterise wave impacts on coastlines and coastal structures. A new small-scale wave flume has been constructed that enables generation of repeatable single wave impacts combined with high quality optical imaging of wave motions and structural deformations. Free-surface time-history and particle tracking based full-field fluid flow measurement systems have been implemented.

Results from studies of wave motions along the flume and for impacts on a cylinder and a vertical wall will be presented and compared to predictions from 2D and 3D volume of fluid based numerical models.

Bradley Boyd, University of Canterbury

Numerical simulations of an acoustically-driven cavitation bubble near a wall: investigation of the growth and collapse behavior at various standoff distances

A high-order accurate, fully compressible, multiphase model is used to simulate the acoustically-driven growth and collapse of a cavitation bubble in water. The model is used to investigate the growth of a near-wall bubble and the subsequent collapse when the bubble is positioned in an acoustic field. The growth phase of the near-wall bubble is studied: the influences of the wall and the acoustic field are investigated. The near-wall is found to significantly restrict the growth of the bubble, with decreasing influence as the bubble standoff distance from the wall is increased. The variation in the standing pressure wave of the acoustic field is also found to be an important consideration, as a reduction in the acoustic driving pressure results in less bubble growth and, subsequently, a less violent collapse.

Matheu Broom, The University of Auckland

Symmetry splitting of impacting droplets on partly wetting surfaces

Impact of liquid droplets on solid surfaces is of importance in many industrial and natural processes. Although water repellence induced by surface roughness is mostly understood in static systems, the influence of roughness on dynamic systems is less obvious. Of interest in this study is the quantitative dependence of impacting droplet shapes on surface patterning, which has previously been approached qualitatively.

This presentation advances on previous work with the aim of explaining the emergence of fingers in the outer rim of a drop spreading on patterned microstructures. In addition, the shape and size of the fully wetted region of the microstructure is described as a function of the impact energetics and the microstructure design. These outcomes are influenced by the details of flow during the early stages of drop impact. Using high speed – high magnification imaging, a description of flow through the microstructure will be presented.

Alan Caughley, Callaghan Innovation

Modelling of Bitumen Emulsion

Road Science, a division of Downer, is dedicated to leading transport technology in New Zealand. Chip sealed road surfaces in New Zealand have traditionally used hot bitumen, thinned with kerosene, as the substrate for the gravel. The bitumen-kerosene mixture is sprayed at 170 °C, requires significant energy during application and has over-spray issues. Additionally, the flash point of kerosene is 40 °C which makes the process highly prone to fire and explosions. At least 3 spray trucks, worth approximately $1M each, have been lost to fire since 2013. Emulsifying the bitumen with water produces a safer, sprayable liquid that overcomes many of these problems and can be used at lower temperatures. The goal is to spray at the lowest temperature possible to reduce operating costs and increase safety.

Road Science and Callaghan Innovation have been working together to characterise the highly non-Newtonian flow properties of the bitumen emulsion and to model its flow through components of the spray truck rig with the aim of optimising performance for low temperature spraying. This presentation describes the journey from developing a fluid model for the emulsion, experimentally validating the fluid model, and then applying that model to a spray nozzle using ANSYS® CFX

Jason Chen, University of Canterbury

Modelling the lifecycle of amorphous silica scaling during geothermal reinjection

When cooled geothermal brine is reinjected, colloidal silica may form, deposit, and eventually block the fluid pathways in the aquifer, reducing injectivity. Models of silica deposition, the formation of colloidal silica, especially the growth of silica nanoparticles over time, are of value in the prediction of geothermal well lifetime and the effects of brine treatments and workovers.

A 2D Eulerian model to predict the in situ and time-resolved physical and chemical conditions and deposition rate of silica is proposed. The driving mechanisms of colloidal silica transport considered in the model are diffusion, convection (Levich 1962), and five external forces acting on individual suspended silica nanoparticles: gravity, buoyancy, London-van der Waals force, electrostatic force, and Saffman lift force. The Saffman lift force and gravity are shown to be negligible. The modelling results are compared to the observations of Mroczek et al. 2017, in experiments with natural brines in which colloidal silica deposition is suppressed by ageing the brine.

This presentation will discuss the authors' recent progress on the modelling of silica scaling, especially with respect to the predictions of size and interactions of silica nanoparticles, and potential future research opportunities on silica inhibition strategies.

This is joint work with Shuying Chen, Kevin Brown and Mark Jermy.

Illia Chryva, University of Canterbury

Rotor-rotor interaction of remotely piloted multicopters and their influence on an on-board spraying system

Remotely piloted multicopters offer low-cost, low-risk precision aerial spraying capabilities. Optimizing spraying from quadcopters requires an understanding of spray behavior when influenced by the downwash of propellers. The problem becomes more complex with increasing number of rotors. An experiment was set up to investigate the flow field dynamics of a multi-rotor array and the impact of the downwash on the spray droplet trajectories. PIV was used to quantify the velocity fields under the rotors. A Laskin seeder unit was developed to produce tracer particles. Preceding studies observed fluctuations in the lift force due to the close position of neighboring propellers. Additionally, turbulence kinetic energy is different for a single propeller and two propellers in the zone of their interaction. These effects are expected to influence the dispersion of airborne droplets. We conclude that it is important to understand the behavior of the downwash in the interaction zone to predict the behavior of spray as accurate as possible. This hypothesis is supported by the outcome of the PIV experiment that will be presented at the FINZ conference.

Richard Clarke, University of Auckland

Permeability as a function of microstructure in the endothelial glycocalyx

The Endothelial Glycocalyx Layer (EGL) is a thin, brush-like layer that coats the inside of the vasculature. It is believed to serve as a protective barrier against excessive fluid shear, as well as a number of other biological functions such as mechanotransduction. In the past the EGL has been modelled as an isotropic, homogenisation porous layer. However, there is an increasing volume of experimental evidence to suggest that the EGL has a microstructural organisation that brings into question this assumption. This study uses Homogenisation Theory, applied on a 2D surface embedded in 3D space, to analyse the extent to which anisotropy on the microscale can lead to anisotropy on the bulk scale.

Jacob Cohen, Technion-Israel Institute of Technology

Subcritical transition in wall-bounded shear flows

A sub-critical transition scenario of wall-bounded flows which are stable with respect to infinitesimal small disturbances (Couette flow and Plane Poiseuille flow for subcritical Reynold numbers), is proposed. Accordingly, a linear transient growth mechanism is initiated by four decaying normal modes, the initial structure of which corresponds to counter-rotating vortex pairs. It is shown that the four modes, are enough to capture the transient growth mechanism. Furthermore, it is demonstrated that the kinetic energy growth of the initial disturbance is not the key parameter in this transition mechanism. Rather, it is the ability of the transient growth process to generate inflection points in the wall-normal or spanwise directions and consequently to make the flow susceptible to three-dimensional disturbances leading to transition to turbulence. The model utilizes separation of scales between the slowly evolving base-flow and the rapidly evolving secondary disturbance to capture most transition stages using the multiple time scales method. Most of the transition key stages are followed analytically. The theoretical predictions are compared with direct numerical simulations and very good agreement with respect to the growth of the disturbance energy and associated vortical structures is observed, up to the final stage just before the breakdown to turbulence.

Paul Docherty, University of Canterbury

Integral-based reconstruction of static pressure in a compliant axisymmetric vessel using velocity field data from particle image velocimetry (PIV) analysis

Particle image velocimetry (PIV) measurement can quantify the velocity fields in a wide variety of situations. This research presents an integral-based approach for pressure field reconstruction from velocity field data. The method directly integrates the Navier-Stokes equation (NSE) across the domain to determine a relative pressure field. If pressure is known at a particular point, the absolute pressure across the domain can be determined. The integral method was used to determine pulsatile pressure distribution from velocity fields (N=22) in a compliant phantom of an axisymmetric stenosed artery. Boundary deflections of the vessel upstream of the stenosis were used to determine the pressure at the vessel wall at that point. This value was used to determine pressure across the vessel domain. The boundary deflection downstream of the stenosis was also used to determine a pressure value which could be correlated to the derived pressure value via integral-based reconstruction. The median reconstruction overestimation of pressure during the pulse wave was 8.5% (Q1=3.3%, Q3=14.4%). The discrepancy could be due to inaccuracy in the trapezium based integration, inaccuracies in phantom construction, or unmodelled behavior such as shear thinning of the working fluid.

Ahmadreza Ebadati, The University of Auckland

Modelling of wave run-up for coastal structures

Ocean waves can damage infrastructure along the coastline, so studying them is of great importance for countries with vast shorelines like New Zealand. Different aspects of the study include wave run-up as well as wave pressures and forces exerted on the coastal defences. The run-up of harmonic and solitary non-breaking long waves over idealised beach topography is investigated, yielding a series solution. Linear theory is used to predict the maximum wave run-up for simple geometry in the absence of a fully nonlinear solution. In the case of a parabolic topography, the result was found to be the solution of either a Legendre differential equation or a second-order Cauchy-Euler differential equation. The effect of the vertical wall (including wave reflections) will be included in an extension of the mathematical model for wave run-up. Results will be presented comparing the mathematical model predictions with several numerical simulations and experimental measurements for run-up on a plane beach. Further work will investigate the pressures and forces exerted on the seawalls and breakwaters during wave impact events.

Zeineldin Elserfy, University of Auckland

Reduction of wind turbine noise using porous trailing edges

Wind energy has great potential for substituting fossil fuel based energy sources, but aeroacoustic noise disturbance produced by wind turbines is one of the major concerns when wind farms are built near urban areas. Trailing edge noise is considered as the main source of wind turbines aerofoil self-noise. It is produced by two different mechanisms, the first one is the blunt trailing edge vortex-shedding noise that occurs when aerofoil has trailing edge of finite thickness resulting in a blunt base. The second is turbulent boundary layer trailing edge noise that is generated as result of scattering of turbulent eddies with the blade boundary layer at the trailing edge. One of the passive techniques for reducing this noise is using porous materials at the trailing edge. The aim of this study is to carry out a numerical investigation using OpenFOAM to study the effect of using porous material on reducing noise intensity by allowing flow transpiration through pores. The current progress is validation for flow around aerofoils (NACA 0012-S809) using RANS turbulent models. In addition, flow through porous media is studied using Darcy- Forchheimer and compared to theoretical and numerical results.

Martin Forbes, School of Surveying, University of Otago

Modelling rifts of the Ross Ice Shelf

Tabular icebergs separate from ice shelves at long, through-cutting rifts that form transverse to ice flow near the seaward fronts of the shelves. The formation and propagation of rifts transpires over time scales from days to decades, making observational studies rare. Thus, while ice shelf rifts represent a critical component in understanding and making projections of future Antarctic mass-balance they are not well understood or represented in models, beyond idealised cases.

This work describes and demonstrates a method for modeling the horizontal propagation of through-cutting rifts in shelves. We use the Ice Sheet System Model (ISSM), to model the flow of ice in the northeast front of the Ross Ice Shelf (Larour and others, 2012). Boundary conditions and imposed nodal load forces are used to correlate the stresses in a smaller elastic domain with those of our flow model. The extended finite element method is then used to solve the elastic domain with added digitized rift. Linear fracture mechanics can then be used to predict the rift propagation propensity and direction.

E. Larour, H. Seroussi, M. Morlighem, and E. Rignot (2012), Continental scale, high order, high spatial resolution, ice sheet modeling using the Ice Sheet System Model, J. Geophys. Res., 117, F01022.

Alice Harang, University of Otago

Numerical study of mudflow resuspension in estuaries: influence of the viscosity and viscoplastic threshold on shear instabilities

This study aims to better understand the mechanism of resuspension of cohesive sediments in estuaries by focusing on the temporal evolution of a layer of mudflow sheared by water. Mudflow, or mud partially consolidated, is modeled by an equivalent homogenous fluid miscible in water with a viscoplastic rheology.

The sensitivity to various parameters such as the viscoplastic yield stress, viscosities or the thicknesses of the velocity or density initial profiles are analysed through numerical simulations using a Navier-Stokes solver. Two types of instabilities, similar to the Kelvin-Helmholtz and Holmboe ones, are put forward. A focus is brought on the mean flow transport with potential application to sediment flux quantifications.

James Hewett, University of Canterbury

Viscous dampers with circular orifices using silicone oil

Viscous dampers are often used in high-rise buildings as a tool for mitigating dynamic loads, typically from earthquake ground motions. In this work, we simulated a fluid damper with a circular orifice using a prescribed sinusoidal piston displacement and calculated the corresponding force exerted on the fluid. We compared our results with experimental observations of force-displacement and force-velocity profiles, confirming that the highly viscous silicone oil was non-Newtonian. We modelled the rheology of the fluid using both the Newtonian and Carreau constitutive equations. The Newtonian model significantly overestimated the force on the piston and the Carreau model only slightly overestimated the force. Neither of these rheological models captured the hysteresis loop observed in the experiments, which might be explained by the fluid exhibiting viscoelastic behaviour.

Natalia Kabaliuk, University of Canterbury

Dynamics of Drip Bloodstain Formation on Fabrics: How Big Can Small Be?

Bloodstained clothing is often submitted to forensic laboratories for Bloodstain Pattern Analysis (BPA) examination. The process of bloodstain formation on apparel fabrics, however, is complicated by a number of factors, such as fibre content, fabric structure and texture. Small blood stains are often found on a suspect's clothing. These may arise from passive dripping and not carry incriminating consequences. Alternatively, small bloodstains may be a result of blood spattering often carrying more sinister implications. To what extent does the fabric affect bloodstain size? What is the smallest realistic passive bloodstain size likely to be produced? Passive blood dripping on a range of commercially available fabrics was systematically investigated using high-speed imaging. A hypodermic needle, a knife and a pipette were used to generate representative droplets. A hypodermic needle produced droplets of 2.4 ± 0.15 mm in diameter. This dripping event resulted in stain sizes both smaller and considerably larger than the corresponding drop size on different fabrics. The stain sizes produced on man-made fleece and man-made Bemsilk lining, in particular, were 2.16 ± 0.19 mm^2 and 10.44 ± 0.19 mm^2, respectively. The study highlighted the importance of considering the fabric properties prior to interpreting bloodstain evidence on fabrics.

Santhosh Kumar, The University of Auckland

Drop Impact of High Viscosity and Non-Newtonian Fluids on Patterned Polymer Surfaces

Interactions of fluids with micro-patterned surfaces are important for numerous microfluidic applications such as surgical endoscopes, biological fluids, MEMS, and applications related to cell growth platforms. Profound developments in high speed photography and microfabrication have led to detailed investigation of dynamic interactions between water drops and patterned surfaces. Drop impact of high viscosity and non-Newtonian fluids on patterned surfaces is of significant additional interest due to common use of such fluids in industrial and biological processes. In this research, aqueous solutions of glycerol and carbopol will be used in drop impact experiments on micropillar arrays. Impact outcomes such as drop spreading and microstructure penetration will be analysed and compared with results for water. The dependence of asymmetric patterns on the array structure will be studied, and the effect of impact velocity will be investigated. To investigate the rebounding of non-Newtonian fluids on patterned pillar surfaces their retraction rate can be measured using high speed photography. The relation between retraction rate and Ohnesorge number (Oh) is essential to understand the transformation from inertial to viscous regimes.

Theodore Lerios, University of Canterbury

Determining changes in patient respiratory mechanics using non-linear autoregressive models of pulmonary elastance

Patients in the intensive care unit (ICU) suffering from acute respiratory distress syndrome (ARDS) require mechanical ventilation (MV) as an essential therapy. Optimal MV algorithms that use patient specific respiratory models may mitigate ventilator induced lung injury (VILI). Improving model descriptions of patient dysfunction may enable optimal MV treatment. Mechanical properties of the lung such as resistance and elastance are important determining factors when creating these models. This study advances a model of respiratory elastance with 19 critically ill respiratory patients undergoing various MV strategies. The patients cover a range of critical illnesses including pneumonia, lung contusion, and brain injury. Current models fail to capture the changes in patient behavior observed in the data sets. This research introduced model variables that allowed the changes in pulmonary mechanic properties that manifested over periods of hours to be captured by the model. This modelling approach is the first step toward a bank of patient changes and responses to therapy that can ultimately be used to power a stochastic model-based algorithm for decision support. If successful, this approach can reduce the cost of ICU admission and reduce the financial strain on health care systems.

Luke Longworth, University of Canterbury

Electrostatic spraying to increase efficiency and reduce pollution

Spraying is used to control pests in most of the high-volume fruit crops grown commercially in NZ (e.g. wine grapes, apples, summer fruit). Typically, excess spray is applied to achieve adequate surface coverage, which results in loss of valuable chemical, and sometimes pollution, by spray drift and absorption into groundwater. Covering the rear faces of fruits or leaves is particularly difficult. Electrostatically charging the spray can alleviate these issues, introducing additional attractive forces to the sides and backs of the target plant. In this work, an induction-charging nozzle was used to spray plants indoors, with coverage assessed by imaging, weighing and using surface wetness sensors. Charging the spray resulted in a slight increase to the total mass deposition on average compared to uncharged spray. Areal coverage on the backs of leaves can be increased by up to 3.5 times by charging. These increased effects should reduce the necessary volume of spray material (thus reducing pollution) whilst still increasing the quality of the coverage. Currently these tests are being extended to outdoor trials. A cart equipped with electrostatics, proximity sensing and a nozzle is being used in a vineyard to test the coverage on grapevines.

Arun Kumar Manickavasagam, University of Canterbury

Effects of non-neighbouring members in small-sized arrays

High speed non-contact AFM (atomic force microscopy/-e) is used to track the motion of live-cells as it ensures no damage to soft biological samples. PRONANO array technology consisting of multiple cantilever beams have been used to achieve faster scan rates. However, the technology has not been established for fluids yet, in which the biological samples are preserved.

Hydrodynamic coupling effects of a pair of cantilevers of arbitrary profiles in an infinite fluid medium have been studied for different configurations theoretically and experimentally. Here we investigate the fluid coupling effects between members of a three and a five beam array with and without the incorporation of non-neighbouring members to understand their significance on the overall array dynamics. Our analysis is based on Navier-Stokes equation for incompressible flow which are solved using a boundary integral technique resulting in hydrodynamic coupling matrices through which added mass and dissipation effects can be inferred.

While nearest neighbour effects have been studied in detail for different configurations of a pair of cantilevers, we specifically focus on the effects of non-neighbouring members in a small-sized array and conclude that non-neighbouring members play a significant role with increasing members in the array especially for gaps smaller than 0.4.

Craig McConnochie, University of Canterbury

Enhanced entrainment into turbulent plumes driven by suspended sediment

We present results from laboratory experiments that examine entrainment into particle-laden turbulent plumes. Specifically, we consider a regime with dilute concentrations of small and dense particles carried by a positively buoyant plume. Within this regime, the settling velocity of the particles is smaller than and in the opposite direction to the plume velocity at all heights.

Despite the settling velocity being much smaller than the plume velocity, the presence of suspended particles is seen to enhance the entrainment of ambient fluid into the plume by approximately 30%. The increased entrainment coefficient is attributed to inertial clustering of the particles leading to regions of the plume being denser than the ambient fluid. We hypothesize that these dense regions can then be convectively unstable leading to an increased entrainment coefficient.

Finally we show that the enhanced entrainment into such plumes can have first order effects on the melting of vertical ice faces that are adjacent to particle-laden plumes. This result could be important for the mass balance of the Greenland Ice Sheet as the subglacial discharge plumes that are present at many of Greenland's glaciers have large concentrations of suspended sediment.

Ryan McKinlay, Callaghan Innovation

Water tunnel design and commissioning

A new water tunnel facility has been designed and built at Callaghan Innovation's Christchurch site. The water tunnel can be used for a wide variety of testing including hydrodynamics of submerged structures, free surface hydrodynamics, propeller cavitation and propeller performance evaluation. This talk will give a general overview of the water tunnel design and discuss some of the challenges that were encountered during commissioning. Initial work has been focussed on propeller performance evaluation requiring high precision and good repeatability. However, tests revealed significant inconsistency in the measurement of propeller torque. An investigation into the influence of the shaft seal arrangement will be described and results presented.

Alex Meredith, University of Canterbury

Interactions between developed gravity currents and rough boundaries

Gravity currents are primarily horizontal flows driven by differing densities between or within fluids. They are ubiquitous in natural environments and are commonly generated by human activities. While the majority of research has investigated gravity currents with smooth beds, many environments where they occur include bottom roughness. Examples include ocean currents travelling over complicated topography or atmospheric currents interacting with cities. Recent studies have considered how gravity currents interact with arrays of idealised solid cylinders. These identified multiple regimes that govern this interaction depending on the array density and layout.

While these studies investigated roughness that was present at the currents' generation and was uniform throughout, roughness in the natural environment is not always uniform. This study, therefore investigated how a developed current interacted with these arrays. This laboratory study was carried out using a lock exchange technique, wherein a constant volume of dense fluid was suddenly released into a channel filled with light fluid where velocity and density fields were measured. These currents were observed to not contain enough energy to overcome the roughness so upon interaction a bore was propagated downstream, allowing the current a constant speed propagation. The current was then seen diluting as it propagated forward.

Emilia Nowak, Massey University

On the vortex formation upon drops coalescence

What will happen upon merging of miscible drops that have different composition?

Typical investigation of coalescence involves same drops, however merging of dissimilar drops, being of different size and/or composition remains an open question, potentially an essential part of multiple existing and promising applications. Till now there is still a lack of understanding of the effect of the various factors involved on the kinetics of coalescence in such set up and the rate of mixing of the contents of the drops.

Binary merging of drops having different compositions, with and without surfactant, results in spontaneous flow inside the merged drops that does not occur when similar drops merge. The difference in interfacial tension between drops/oil causes difference in pressure and upon coalescence, the higher pressure drop is injected inside the low pressure drop with accompanying interfacial flow. The degree of these convective motions is dictated by the viscosity of the aqueous drops and surrounding drops immiscible oil and at high viscosity surrounding oil, the injection of one drop inside another produces vortex ring - as the viscosity of drops increase, the vortex ring is no longer occurring and in this work we are trying to explain this transition.

Thiwanka Palmada Kankanamalage, Auckland Bioengineering Institute

Modelling flow and mixing in the proximal small intestine

The small intestine is the primary site of enzymatic digestion and nutrient absorption in humans. Intestinal contractions facilitate digesta mixing, transport and nutrient absorption. Motility patterns consist of two types of contractions: longitudinal (peristaltic) contractions that propel digesta towards the colon and segmentation contractions that mix the digesta. We carried out CFD simulations in order to understand the role of the different motility patterns and digesta rheology in the mixing and emptying of food contents. Using the OpenFOAM computational library, peristaltic and segmentation contractions were implemented on a realistic geometry of the duodenum. The effects of varying the amplitude and wave speed of the contractions and the rheology of the digesta on digesta velocity and mixing were studied. Laminar flow was observed with interesting flow features such as stagnation points and reverse flows being present.

Existing CFD models of the small intestine use simplistic geometries and mechanical contractions, therefore in the future, CFD simulations will be carried out using mechanical contractions derived from electrophysiological data. These models developed can be used to facilitate the design of "functional foods" for targeted delivery of nutrients and/or treatment of diseases.

Lily Panton, The University of Auckland

Experimental study of evolution of drop impact force

A highly sensitive piezoelectric pressure sensor is used along with high speed camera footage to probe the force beneath droplets impacting on solid surfaces. The experimental procedure is validated by integrating the force-time profiles and comparing with known drop momentum. Dimensionless force-time profiles are found and the key characteristics (such as peak force) of these profiles are studied for varying Reynolds number. Both water droplets and silicone oil droplets (with a viscosity of 350 cSt) are considered, and drop diameters in the range 1.5-3 mm for velocities up to 2.5 m/s are studied. In the case of water droplets an unwanted interaction between the piezoelectric sensor and droplets occurs, but this may be effectively removed by using droplets of silicone oil (a non-polar fluid). While drop-impact force profiles are of interest for various applications, the main application considered here is for modelling rain noise and a discussion of improving existing rain noise models based on the impact-force data collected is given.

Scott Post, Lincoln Agritech

Granular flow properties of lime

Whether spread by truck or by airplane, agricultural limestone presents some challenging granular flow problems due to its cohesiveness. Its cohesiveness causes it to come off the truck's conveyer belt in discrete cakes rather than as a continuous flow, resulting in uneven spread patterns on the ground. For airplane spreading, there is a danger of the lime forming a bridge or arch in the hopper, which not only prevents flow, but can be safety concern if the pilot needs to reduce weight for manoeuvring. The cohesiveness of lime is related to the moisture content and the particle size distribution. The flowability of the lime can be correlated with the uniformity index (or standard deviation) of the particle size distribution.

James Ramsay, University of Canterbury

Preventing boundary layer separation with non-uniform suction

Suction of the boundary layer has long been investigated as an effective method for preventing or delaying its separation. The main body of this research has focussed on the reduction of drag without investigating the direct effect on the point of separation – the key contributor to the development of pressure drag. Furthermore, most research in this area has employed uniform suction over the entire body surface or else suction through discrete slots – each of these methods has disadvantages. A better approach might be continuous non-uniform suction, where an arbitrary suction profile can be applied over all or part of the body. The present research carried out numerical investigations to determine the optimum non-uniform suction profiles on a 2-D circular cylinder in an incompressible cross-flow at low Reynolds number ($\mathrm{Re} < 200$). Optimum suction profiles were determined for this Re range which successfully eliminated separation with as little as half the control effort required by uniform suction. Relationships between the suction effort, location of suction, the uncontrolled separation angle, and the Reynolds number were determined which suggest that these results can be extended into higher, more practical Re ranges.

Natalie Robinson, NIWA

Physics of the ice-ocean boundary layer in the presence of accreted ice crystals

Melting by the ocean currently dominates mass loss from Antarctic Ice Shelves. The meltwater can become supercooled through pressure-relief, thus allowing suspended ice seeds to grow into disc-shaped crystals that can buoyantly accrete beneath solid ice cover. The presence of these crystals, known as 'platelet ice', profoundly affects both thermodynamic and hydrodynamic interactions at the ice-ocean interface. However, there is presently no representation of these effects in numerical models of ice-ocean interaction. Here we present data from several field campaigns which reveal two distinct mechanisms by which platelet layers modify ice-ocean interactions: (i) extreme effective roughness arises through four modes that may operate independently or simultaneously; and (ii) ice growth onto both accreted and suspended crystals quenches supercooling and introduces spatially-variable convective mixing along the flow path. We are working towards quantifiable relationships between the upstream conditions; platelet layer thickness; and the longevity of supercooled Ice Shelf Water with distance from the calving front; which are intended to inform under-ice boundary layer parameterisations.

Pete Russell, Department of Marine Science University of Otago

High resolution observations of an outer bank cell of secondary circulation in a natural river bend

Vertical shear in curved flows induces secondary circulation in the plane normal to the primary flow direction. Recent models for secondary circulation include the ‘non-linear’ advection terms in the momentum equations. A consequence of this is that secondary circulation deforms the vertical profile of the primary flow. This in turn reduces the vertical shear of the primary flow thus reducing the driving force of secondary circulation. Observations from a bend in the Clutha river show flattening and deformation of the vertical profile of the primary flow due to the advection of momentum by secondary circulation. A counter rotating outer-bank cell of secondary circulation is associated with this deformation. A visual explanation for this outer bank cell is proposed, based around the forces of plane equilibrium and the deformation of the vertical profile of the primary flow. A suggested requirement for a counter rotating outer-bank cell is that the depth average velocity must be found at two depth locations on the vertical profile of the primary flow. The width of this outer bank cell is twice that of previous flume experiments, perhaps due to outer bank roughness. The strength of this outer bank cell is approximately 0.5 of the main cell.

Mathieu Sellier, University of Canterbury

Modelling the flow in a fracture network by patching Hele-Shaw cells

Over time, the extraction and reinjection of geothermal fluid to generate electricity results in a decrease in the overall pressure of a geothermal reservoir. This results in the precipitation of minerals that causes blockages in the power station equipment and the rock fractures in the reservoir; as well as a lower flow rate available for electricity generation. A better understanding of the fluid flow in a fracture network is required to better predict the performance of the reservoir over time. Modelling the flow in a fracture networks is however very challenging because of the wide range of length scales involved: a fracture aperture can be on the order of millimetres but spans kilometres. The Hele-Shaw approximation has been shown to be a useful model to represent the flow through a single fracture. This talk will discuss how multiple intersecting fractures forming a network can be modelled by connecting Hele-Shaw cells.

Jonathan Squire, University of Otago

The interesting fluid dynamics of planet formation

A great uncertainty in current theories of planet formation concerns how dust grows in size from millimeter-scale grains up to kilometer-sized planetesimals. Not only are particles in this size range moving sufficiently fast to shatter in collisions, rather than stick together, they also quickly fall through the protoplanetary accretion disk into the central star. The solution to this problem likely lies in the collective fluid dynamics of dust and gas, which interact through drag forces and are often unstable to ”Resonant Drag Instabilities.” These instabilities act to clump dust as it moves through the gas in various ways, seeding high-density regions that may in turn collapse under self gravity.

Craig Stevens, NIWA/University of Auckland

Ocean Mixing at Large Reynolds Number: Observations from Cook Strait

There remains much to be learned about the full range of turbulent motions in the ocean. There is a something of a bias away from measurements in highly energetic waters due to operational challenges. The relatively shallow, weakly stratified, fast-flowing tidal flows of Cook Strait, New Zealand provides opportunities to examine a range of turbulent scales including high Reynolds Number. With flow speeds reaching 3m/s in a water column of 300m depth, the location is heuristically reckoned to be highly turbulent. Here I will discuss recent and upcoming efforts to generate an observational basis for this. This includes a description of the flow structure, stratification and turbulent scales such as the Ozmidov and Thorpe scales.

Zhifa Sun, Otago University

Rayleigh-Bénard-Marangoni cellular convection with transient gas-liquid mass transfer

In gas-liquid heat and mass transfer processes, Rayleigh-Bénard-Marangoni (RBM) convection can facilitate heat and mass transfer across the gas-liquid interface, enhancing the transfer rate by several folds with respect to a purely conductive/diffusive mechanism.

To predict onset of RBM convection in gas-liquid solute-transfer systems with transient penetration type base solute concentration profiles, a method of spatial base-profile influenced frozen-time marginal state analysis has been developed. To determine convective amplitude of RBM convection, stochastic Ginzburg-Landau equations for the symmetry-breaking non-equilibrium phase transition of RBM convection have been developed. The models take into account the effects of thermodynamic fluctuations and the effects of spatially inhomogeneous advection. The Ginzburg-Landau equations have been solved numerically using spectral methods to investigate the relative contribution of the Rayleigh and Marangoni effects on convective amplitudes and transitions between convective flow patterns. Complex convective structures, such as vortex motion formed at the centre of hexagonal convection cells, have been obtained from numerical investigations using the model. Theoretical analysis and model results of onset and convective amplitude of RBM convection will be discussed in this presentation.

Sarah Wakes, University of Otago

Understanding the stall behaviour of a one-blade wind turbine

Utilising New Zealand's winds for optimum power production for small-scale use requires a robust, efficient wind turbine. Thinair 102 is a one blade downwind stall-regulated turbine designed to maximise power in gusty winds. However, rapid variations in Tip Speed Ratio (TSR) due to wind speed can be detrimental to the turbine and controller from the changing blade stall fraction over very short time periods. In order to optimise future blade design and improve the response of the control system to such fluctuations in power output understanding stall on the blade is crucial. This presentation will outline the methods used to measure and predict stall on this blade and how this can be used to inform the design of a larger blade.

Frederick Wells, University of Auckland

Milk spray drying without sticking

Milk is sticky. It becomes shear-thinning when concentrated, and droplets form a viscous skin when heated. These properties lead to interesting drop impact phenomena, and a multi-million dollar problem for the dairy industry.

Industrial spray dryers produce powder from liquid food products by allowing small droplets to fall through heated, dried air, but suffer from major blockages when partially-dried product sticks to the steel walls. We address this problem by understanding and controlling the behaviour of individual impacts. Single drops of milk were impacted onto steel surfaces mimicking the internal surfaces of industrial spray dryers, and recorded with high-speed cameras. We are building a temperature- and humidity-controlled chamber to measure droplets under typical industrial conditions: 200°C and 3g/kg moisture, before varying these conditions to reduce sticking.

Continuum Fluid Dynamics simulations of droplets impacting a rough surface show an optimal surface asperity height to promote splashing and reduce residue. This suggests that fine-tuning roughness may reduce sticking. To see this experimentally, we are investigating different steel grades and finishes. The next step will be to apply and test several techniques to reduce dynamic adhesion, including modification to surface structure and material, local airflow, temperature, and humidity.

Colin Whittaker, The University of Auckland

Lagrangian particle transport by wave groups in finite water depth

The transport of particles by waves, and particularly wave groups, is important when determining the fate of plastic waste in the ocean. This wave-induced transport depends on the net forward transport by Stokes Drift and the Eulerian return flow. The set-down of the free surface beneath wave groups in finite water depth, and the error wave arising from incorrectly generating this set-down in laboratory experiments, also affect the particle transport.

This paper presents a series of particle tracking velocimetry (PTV) experiments to measure the trajectories and net displacements of particles transported by wave groups with a Gaussian spectral shape in finite water depth. Processing of results to account for background particle motion and the second-order error wave will be discussed. The experimental measurements are compared to the predictions of a multiple-scales derivation for Lagrangian particle transport in arbitrary water depth. The results demonstrate the importance of the set-down in forcing the mean flow, and hence in determining the depth at which the net particle displacement transitions from positive to negative. Extensions to finite-size particles will be discussed.

Ben Wilks, University of Otago

Scattering Modes of Cylindrical Helmholtz Resonators

A water wave resonator consisting of a hollow and rigid bottom-mounted cylinder which is partially open along its vertical and azimuthal dimensions is considered. The opening between the interior and exterior fluid domains allows for the phenomenon of Helmholtz resonance to occur. A boundary value problem based on linear water wave theory is formulated and a solution based on the integral equation/Galerkin method is devised. The scattering coefficients which arise from this solution method are used to calculate the scattering cross section (SCS) for the resonator. Peaks in the SCS are associated with resonances of the system. The SCS is further decomposed into scattering modes allowing us to identify which wave modes contribute to each resonant peak. The solution method is then extended to complex-valued frequencies. The scattering modes are approximated using truncated Weierstrass factorisation involving the poles and zeros of the scattering coefficients, subject to some as yet unresolved scaling factor.

Petra Williamson, University of Canterbury

Particle Image Velocimetry (PIV) Analysis of Haemodynamics Distal of a Frozen Elephant Trunk Stent Phantom

Cardiovascular diseases (CVD) are the leading cause of death in the developed world and aortic aneurysm is a key contributor. Aortic aneurysms typically occur in the thoracic aorta and can extend into the descending aorta. The Frozen Elephant Trunk stent (FET) is one of the leading treatments to seal the aneurysms that extend into the descending aorta. This study investigates pulsatile haemodynamics in a compliant phantom of the descending aorta containing a stent surrogate. A silicone phantom was manufactured using a lost core casting method. A thin walled, radially rigid PVC stent was manufactured using the same mould core. Planar particle image velocimetry (PIV) was used to visualise the pulsatile flow, focusing specifically on the passive fixation at the distal end of the FET. The results showed an apparent expansion in the deceleration phase of systole and diastole that was identified to be a collapse in the lateral plane. Vortices were identified during this collapse. The collapse was attributed to a low upstream pressure and high downstream pressure causing a vacuum effect. This collapse may imply a potential risk introduced by the FET stent in vivo that requires further investigation.

Geoff Willmott, The University of Auckland

Inertial capillary uptake of droplets

Capillary uptake is a ubiquitous phenomenon in nature and industry, relevant wherever liquid interfaces are confined to small spaces – irrigation, printing, and microfluidic devices are some examples. The archetypal experiment for studying capillarity involves uptake from a large reservoir into a vertical, cylindrical tube. Various dynamic regimes for uptake have been identified using capillary tubes, including the well-known Lucas-Washburn regime in which meniscus position is proportional to the square root of elapsed time. At earlier times, there is an inertial regime in which meniscus velocity is constant. These dynamics are altered when a drop comes into contact with a droplet, because the Laplace pressure within the droplet can affect the direction and speed of uptake [1]. This presentation will discuss recent experiments in which the droplet is of comparable size to the capillary opening, so that the dynamics become still more interesting. In these experiments, the Laplace pressure is constantly changing with the drop size, and the dynamics are firmly within the inertial regime. High-speed photography allows the droplet and meniscus motion to be explicitly tracked and analysed.

[1] Willmott et al., Soft Matter 7, 2357-2363 (2011).

Sina Yazdi, University of Canterbury

In-vitro measurement of hemodynamics in rigid and compliant silicone replicas of aortic arch using stereoscopic particle image velocimetry

Cardiovascular diseases (CVDs) such as atherosclerosis and aneurysm inhibit healthy haemodynamics in the aortic arch. Fluid dynamics measurements play a crucial role in better understanding of the aortic haemodynamics and disease initiation. Most numerical and experimental studies of aortic haemodynamics have been limited by the rigid boundary assumptions or inaccurate complaint phantom manufacturing. The aim of this study was to measure the effect of compliance on aortic haemodynamics in an accurate physiological phantom. Rigid and complaint silicone phantoms of the aortic arch were fabricated using a lost-core casting method. Stereoscopic particle image velocimetry (SPIV) was used to capture the pulsatile velocity fields. The results showed the peak velocity in the compliant phantom compared was lower than in the rigid phantom during accelerating systole. However, during decelerating systole, peak velocity was higher in the compliant phantom and flow recirculation witnessed in the brachiocephalic branch in both phantoms was twice the size in the rigid model. During diastole reverse flow and recirculation were detected in the compliant phantom but not in the rigid phantom. These behaviours were consistent across all measurement plains. The results revealed that the consideration of the wall compliance and pulsatile flow is critically important for clinically relevant outcomes.

This is joint work with P. Docherty (Canterbury), A. Khanafer (Otago), M. Jermy (Canterbury), P. Geoghegan (Birmingham), N. Kabaliuk (Canterbury) and P. N. Williamson (Canterbury).

Posters

Michael Coe, University of Canterbury

UC-Ika Series of Underwater Robots

Underwater robotics is an emerging field. Current trends for these types of robots focus on propulsion based on the steady swimming gait of fish in which the tail moves as a traveling sinusoidal wave. The University of Canterbury has developed three generations of bio-inspired robots that use linkages to replicate these gaits. Steady swimming in fish is an exception, and it has been shown that fish prefer a more efficient burst-and-coast gait. This gait involves the fish accelerating to a high initial velocity and the body is then kept straight by the modulation of lift and drag by median fins with little tail movement. Beyond the burst-and-coast swimming gait, fish fins and a compliant body allow for the modulation of lift and drag during highly mobile turning manoeuvres. This project seeks to create a highly mobile, compliant robotic fish analogue based on previous work at University of Canterbury. We seek to model how compliant propulsive surfaces interact hydrodynamically during locomotion and handle unsteady flows.

This is joint work with Stefanie Gutschmidt (Canterbury)

Bibin Jose, University of Canterbury

A study on the effect of an axisymmetric cavity in coaxial supersonic stream

Mixing of two supersonic streams in short mixing chamber is basic requirement for advanced propulsion systems like air augmented rockets, ramjet, scramjet, supersonic ejectors etc. In all the above concepts a secondary combustion chamber is required to mix the combustion products from primary rocket nozzle with air supplied by air intake system. But it is difficult to achieve proper mixing of primary and secondary flow at supersonic speeds. So certain mixing techniques are used. Generally two methods are employed for this. One is by changing the nozzle geometry and other by inducing shocks, turbulence etc. to the flow by the introduction of cavities. The present study is an experimental and analytical work. The nozzles tested here is conventional convergent divergent with circular exit. The mixing tubes with axisymmetric cavities have an aspect ratio of 5. From the stagnation pressure measurements taken at the exit of mixing tubes the radial momentum distribution is found out. Based on that results are obtained and it shows better mixing for mixing tubes with cavity than without cavity.

This is joint work with Z.A. Samitha (College of Engineering Trivandrum, India).

Vishnu Kuduva, University of Auckland

Resilient heat exchange surface for fouling environments: Can surface functionalization improve heat transfer?

Intriguingly, the advancements in science and technology continue to improve our understanding of something fundamental as frost formation and water droplet interaction with a surface. Although a lot has been known about frost formation through nearly five decades of research, the advancements in surface functionalization have drawn researchers to revisit these frost experiments in lights of surface properties. Thermodynamically, in heat exchange surfaces as the hot and humid air passes across the cold surfaces, the water vapor condenses and results in water fouling. Under certain thermodynamic conditions as in de-sublimation, the moist air can directly deposit as frost on these surfaces. Water fouling and frost formation reduces the heat transfer efficiency and affects the performance of heat exchangers. This project will involve designing a psychrometric wind tunnel to measure heat transfer involved in frost formation of various functionalized surfaces through an experimental design.

Through the collaborative network of NZ Product Accelerator and GNS Science, a number of functionalised surfaces ranging from super-hydrophobic, super-hydrophilic and biphilic-surfaces will be designed and further tested using this psychrometric wind tunnel. The main drivers for investigating these super-hydrophobic and ice-phobic surfaces are its potential energy savings in applications such as in refrigerators,HVAC equipment etc

This is joint work with Mark Philip Taylor (Auckland) and John Kennedy (GNS science).

Sam Lowrey, University of Otago

A survey of optical lithographic techniques for modified surface wetting

Condensation control on heat exchangers (HXs) can yield tremendous heat transfer enhancements of up to 5-7x. Superhydrophobic (SHPB) surfaces can promote dropwise over filmwise condensation thus increasing liquid mobility, reducing thermal resistance and raising heat transfer rates, offering a plethora of applications from self-cleaning surfaces to enhanced efficiency in condensing HXs.

State-of-the-art hierarchical SHPB structures are inspired by the lotus leaf's surface structure, employing randomly distributed nanoscale features. Optical lithography (OL) allows precise control over nanoscale structural geometry, is a relatively low cost micro/nanofabrication technique and allows fast fabrication over relatively large areas compared with other common micro/nanopatterning methods.

Here we present a survey of structures fabricated using OL means and their resultant wetting characteristics along with two novel hierarchical structures.

This is joint work with Jacob Johnston (Otago) and Richard Blaike (Otago).

Ali M. Sefidan, University of Canterbury

Multi-layer Phase Change Materials in tubular and rectangular shaped cylinders

The use of phase change materials (PCMs) has been recommended due to their high capacity of energy saving and delivering arising from phase change process. In addition, a constant temperature of melting or freezing, provides a desirable condition to transfer a large amount of heat with low-temperature fluctuations. This work attempts to present a summary of our recent works related to using multi-layer PCMs in tubular and rectangular shaped cylinders. These numerical studies have been done to simulate PCMs solidification and also simultaneous solidification and melting processes inside double-layer heat exchangers dealing with steady and time-dependent boundary conditions. Numerical models employ the enthalpy-porosity approach based on the finite volume method, which models the phase change on a fixed grid domain. Moreover, in order to produce accurate simulation, fluid flow arising from Boussinesq approximation in the liquid phase is also considered using the PISO algorithm. Since PCMs with various properties respond to the same boundary condition in different ways, results show that using multi-layer PCMs can improve and control the system response to the boundary conditions.

This is joint work with Mathieu Sellier (Canterbury) and Atta Sojoudi (University of Tehran).

Ata Suanda, University of Otago

High-frequency temperature oscillations on the Otago inner shelf

Temperature oscillations in the ocean interior can indicate reversible (wave) and irreversible (mixing) processes important to understanding air-sea exchange and ocean biological activity. A vertical array of fast-response (< 1 s) temperature sensors were deployed to record interior ocean temperature and thermal stratification during Spring, 2018 on the Otago continental shelf (15 m water depth). Over the 1 month observation period, the background water column vertical structure evolved from supporting a near-surface pycnocline, to being characterized by a deep surface mixed layer. A period of destratification related to wind- and surface wave-driven mixing persisted in between. The characteristics of high-frequency temperature oscillations (periods < 30 minutes) similarly evolved in response to variable background, including vertically coherent non-linear internal waves in the form of soliton packets, to vertically non-coherent oscillations. Although internal waves are documented to be important contributors to the transport and mixing of coastal tracers, the origin and fate of waves at this location remains unclear at this time. Neither coherent nor non-coherent high-frequency temperature behaviour is explicitly resolved by current regional ocean circulation models, and efforts to parameterise these effects should be encouraged.

This is joint work with Robert Smith (Otago).

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Practical Information

Getting to the conference

The conference will be held on the University of Otago campus, which is within walking distance of Dunedin city centre. To get to the city from the airport, we recommend that you take a shuttle (no booking required). Note that there are no airport buses in Dunedin.

The next page shows a map of the campus with the conference locations indicated.

Talk sessions and registration

All sessions will be held in the Moot Court lecture theatre, which is located on the **10th floor of the Richardson Building**. The registration desk will be located outside the lecture theatre on Thursday 31st January starting at 8.00am. The red star on the map indicates the location of the Richardson Building.

Poster sessions

The poster sessions will take place during morning tea on both days of the conference, in seminar room 5, just across the hall from the Moot Court lecture theatre. We ask poster presenters to spend some time nearby their poster to discuss their research. You will be able to come in from 8am on Thursday morning to install your poster.

General meeting

A general meeting will be held at 5.30pm on Thursday 31st January in room 241 of the Science III Building, which is located on the 2nd floor. All those interested in the future of the conference are encouraged to attend. The yellow/green star on the campus map indicates the location of the Science III Building.

Morning/afternoon teas and lunches

Morning/afternoon teas and lunches will be provided in the seminar room 5, i.e. where the posters will be on display.

Conference BBQ

The conference BBQ will be held from 6.30pm to 8.30pm on Thursday 31st January in the University Staff Club. The blue star on the campus map indicates the location of the Staff Club.

Internet access

If Eduroam is supported by your home institution, you should be able to connect to the `Eduroam` wireless network. The unencrypted wireless network `UO_Guest` is also available for this conference and provides access to the Internet for up to two weeks, 500MB per day and two devices at a time.

1. Select `UO_Guest` from the list of available networks on your device.
2. If a login windows doesn't appear, open a browser and try to load any web page.
3. Log in if you already have an account, otherwise follow the prompts to create one. When you create an account the login details are displayed on screen. Write these down or take a snapshot for your reference. Your login details are also sent to the email address you supply.

Social media

FiNZ attendees are encouraged to use social media to share ideas and promote the conference. The conference Twitter hashtag is `#finz19`.

Campus map